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Quality Assurance in Support of Energy Related Monitoring Activities: Annual Report No. 3

Rockwell International
Newbury Park, CA

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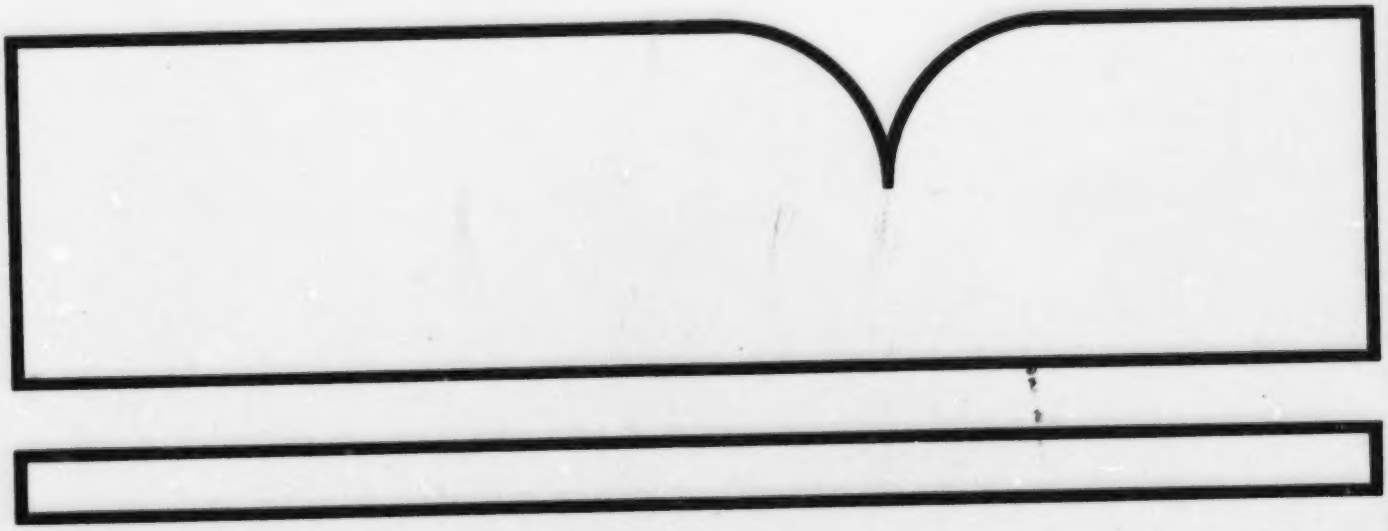

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QUALITY ASSURANCE IN SUPPORT OF ENERGY RELATED MONITORING ACTIVITIES

Annual Report No. 3

by

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16. ABSTRACT

This report describes and summarizes the activities during the third year of the program entitled, Quality Assurance in Support of Energy Related Activities. The activities reported cover the period from October 1, 1978 to September 30, 1979.

The purpose of this program is to establish a quality assurance data base for ambient air monitoring in specified geographical areas around present and proposed energy development projects, and to provide technical assistance to enable monitoring networks to achieve a high level of data quality.

Discussed in this report are the regularly scheduled Quality Control Reference Sample Audits conducted for the analysis of sulfate, nitrate, sulfur dioxide, nitrogen dioxide and carbon monoxide, and for weight measurement and high-volume flow rate. In these surveys reference samples or devices are submitted to participating laboratories and their results compared with those obtained by Rockwell. Performance results for the third year of the program have remained essentially constant for sulfate, nitrate, sulfur dioxide and carbon monoxide. The results for carbon monoxide are noteworthy for their consistently high quality. Results for nitrogen dioxide have shown some improvement, but do not continue the trend indicated in the last three audits of 1978. Improvements in performance have also been quite notable in the high-volume survey.

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ABSTRACT

This report describes and summarizes the activities and achievements of Rockwell International's Environmental Monitoring & Services Center (EMSC) during the third year of the program entitled, Quality Assurance in Support of Energy Related Activities. The activities reported cover the period from October 1, 1978 to September 30, 1979.

The purpose of this program is to establish a quality assurance data base for ambient air monitoring in specified geographical areas around present and proposed energy development projects, and to provide technical assistance to enable existing monitoring networks to achieve a high level of data quality. A major goal of the program is to give the U.S. Environmental Protection Agency (EPA) access to monitoring data from diverse sources for future study and planning purposes. This goal involves providing information concerning data quality from the individual monitoring networks.

Discussed in this report are the regularly scheduled Quality Control Reference Sample Audits conducted for the analysis of sulfate, nitrate, sulfur dioxide, nitrogen dioxide, and carbon monoxide, and for weight measurement and high-volume flow rate. In these surveys reference samples or devices are submitted to participating laboratories and their results compared with those obtained by Rockwell. Performance results for the third year of the program have remained essentially constant for sulfate, nitrate, sulfur dioxide and carbon monoxide. The results for carbon monoxide are noteworthy for their consistently high quality. Results for nitrogen dioxide have shown some improvement, but do not continue the trend indicated in the last three audits of 1978. Improvements in performance have also been quite notable in the high-volume survey. In the 1979 survey approximately 57 percent of the participants had errors of less than or equal to 5 percent, compared to approximately 39 percent with similar errors in the second year and only approximately

20 percent in the first year. Improved performance was also apparent for the weighing survey.

Quarterly Performance Audits at specified monitoring sites are also discussed. In these audits, known concentrations of pollutanta are delivered to each continuous analyzer, and the observed response is compared with that predicted by the agency's calibration. Procedures have been developed to assure reliable performance by the audit devices and standards. Additional checks on the equipment and procedures are made by means of quarterly audits performed by EPA's Environmental Monitoring and Systems Laboratory at Research Triangle Park, North Carolina.

Over 160 Calibration System Audits have been completed during this reporting period, and audit reports have been submitted to EPA. A major achievement of the program has been the remarkable improvement in the calibration accuracy observed for several pollutants, especially nitric oxide, nitrogen dioxide, nitrogen oxides, and ozone. This trend is particularly evident for the year 1979 when the performance of the on-going Western Quality Assurance Program is compared to that for the new participants in the Eastern Quality Assurance Program.

In addition to audit activities, technical assistance has been provided to participating agencies as requested by the Project Officer. Much of this assistance was given informally during site visits. During special visits by Rockwell personnel, assistance was also provided concerning specific laboratory and calibration problems. A brief description of the major area in which technical assistance was needed is given in the report.

This report is submitted in fulfillment of Contract No. 68-02-2412 by Rockwell International's Environmental Monitoring & Services Center under the sponsorship of the U.S. Environmental Protection Agency. Work under this contract is scheduled to be terminated when the current funding is exhausted (approximately December, 1980).

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SECTION 1

INTRODUCTION

The program Quality Assurance in Support of Energy Related Monitoring Activities was initiated on July 13, 1976. Since that date, the contract under which the program is sponsored has undergone several modifications.

On March 24, 1977, the contract was expanded to include additional Quality System Audits and Performance Audits of sites located in Colorado, Utah, and Montana. On August 9, 1977, the contract was further expanded to include Quality System Audits of seven water quality field stations of the U.S. Geological Survey in the states of Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming.

The first major modification to the contract was put into effect September 13, 1978, when the program base was broadened to include laboratories and sites located in the Ohio and Tennessee Valleys, and also in several Eastern states in Region III. Quality System Audits of the 16 new participants were performed and detailed evaluation reports (each containing recommendations for estimating observed deficiencies) were submitted to the EPA Project Officer. At the time of the modification, the work for Region VIII (initiated on March 24, 1977, as described above) was extended for an additional 12 months. Subsequently, in April 1979 the Eastern Agencies associated with the program terminated their participation.

In this report reference is made to the Western Quality Assurance Program and the Eastern Quality Assurance Program. This delineation of the program is employed for convenience in describing work according to the geographical location of the participating groups.

One goal of the Western and Eastern Quality Assurance (QA) Programs is to develop a QA data base for use by air monitoring networks and EPA in energy development projects. A secondary goal is to provide technical assistance to the participating groups to help them achieve a high level of performance. In the West the energy projects are located in the states of Montana, South Dakota, North Dakota, Wyoming, Utah, Colorado, Arizona, Nevada, New Mexico, and California. In the East the energy projects are located in the states of West Virginia, Ohio, Pennsylvania, and Indiana. Additional groups, which are not necessarily involved in energy development projects, are located in Delaware, Maryland, Virginia, and the District of Columbia. These projects are associated with the Eastern QA Program.

This Annual Report is submitted as a general overview of performance and progress thus far. Because the program has been running for three years, the trends towards improved performance are more obvious. In order to keep this report within manageable size, only data summaries are presented. Detailed information on the various tasks performed is contained in specific reports submitted separately to EPA.

The Eastern and Western Quality Assurance Programs are divided into four task areas:

- Quality System Audits - initial on-site reviews of laboratories and field sites.
- Quality Control Reference Sample Audits - sample submission audit program to the laboratories.
- Performance Audits - on-site field calibration audits.
- Technical assistance to the laboratories, as required.

All work carried out by Rockwell in connection with these tasks is summarized in the following sections. Section 2 describes the Quality System Audits, which for this report period focus on the Eastern QA participants. Section 3 discusses the results of the Interlaboratory Reference Sample Audits, and Section 4 summarizes Performance Audits which have been performed on a

quarterly basis in the Western QA Program. In the Eastern QA Program, each site was audited only once before the program was terminated. Section 5 describes technical assistance given to the various agencies.

SECTION 2

QUALITY SYSTEM AUDITS

All Quality System Audits in the Western QA Prgoram were completed during the first year of the contract and were described in the first annual report. The second annual report lists all the agencies participating in the Eastern QA Program. During this reporting period, system evaluations were completed for all agencies in the Eastern QA Program. Table 1 lists these agencies and gives the date of their on-site evaluation.

The evaluation procedure used in the Eastern QA Program involved sending detailed questionnaires to the agency to be audited. After the questionnaires were returned, a site visit was performed by Rockwell personnel. The on-site visit included interviews with in-house personnel inspection of the laboratories, and field inspection of a small sample of monitoring stations belonging to the agency. Each system evaluation was described in a detailed report which was submitted to the EPA Project Officer. The reports contained recommendations on how to correct the indicated deficiencies. The reports also attempted to estimate, quite grossly, the capital outlay necessary for corrective measures and the impact on data quality such steps would have.

PROBLEM AREAS ENCOUNTERED

Staffing and Training

Two agencies when evaluated were found to be understaffed, and one was found lacking in technician training. The organizational structure in one agency is such that the duties are split among various departments, and no one person is in a position of a QA Coordinator to supervise all the QA aspects of the laboratory and network operations.

TABLE 1. SUMMARY OF QUALITY SYSTEM AUDITS
PERFORMED IN THE EASTERN QA PROGRAM *

Agency	Date	Agency	Date
City of Alexandria	8/78	Ohio Edison	2/79
Allegheny County	9/78	Pennsylvania Electric Co.	3/79
City of Baltimore	10/78	State of Pennsylvania	9/78
Baltimore County	10/78	City of Philadelphia	10/78
City of Cincinnati	2/79	RAPCA - Dayton, Ohio	2/79
State of Delaware	10/78	State of Virginia	8/78
Fairfax County	8/78	Washington, DC	8/78
State of Indiana	2/79	State of West Virginia	9/78
State of Maryland	10/78		

* The dates indicate the on-site visit by Rockwell personnel

Quality Assurance Plan

Most of the agencies audited have an outdated QA plan. However, these plans are undergoing revisions to conform to the specific EPA guidelines. Only four agencies have been found completely lacking a QA plan.

Equivalency of Monitors

Six agencies are still operating older monitoring equipment for which there is no EPA equivalency. These monitors will probably be changed, within budgetary constraints, to conform to the State and Local Air Monitoring Stations (SLAMS) network design requirements.

Zero/Span Checks

Most agencies (approximately 13) do not keep records of their routine zero and span checks. This lack of record-keeping makes it very difficult for data validity to be documented. In addition, one agency has indicated that it does not perform routine zero/span checks on its monitors at all.

Multipoint Calibration

Ten agencies were discovered to not be performing routine multi-point calibrations. They use instead only the manufacturer's original calibration and their own zero/span checks.

Traceability of Standards

Twelve of the agencies were found deficient in traceability of standards. For CO and NO cylinders, these agencies did not require a traceability certification from the manufacturer. For SO_2 perm tubes, the accuracy of the bath thermometer was not National Bureau of Standards (NBS) traceable.

Station Flow System

In seven cases the flow system which samples the ambient atmosphere was found inadequate. Common problems encountered were: inadequate flow rate with no permanent device to monitor flow rate, tygon tubing used instead of Teflon tubing, and long sampling lines increasing residence time. A particularly bad practice was exercised by several agencies in which sampling and calibration intake lines were not one and the same.

Zero Air Source

In five agencies insufficient care was exercised with the zero air source, to the extent that no independent check was carried out to determine if interfering impurities were contained in the zero air supplied to the monitors.

Filter Handling and Analysis Procedure

Seven of the laboratories evaluated did not institute appropriate quality control (QC) procedures in their high-volume (Hi-Vol) filter handling. These QC shortcomings included no inspection of filters for pinholes and no reweighing of filters to check for weighing errors. In one instance, no environmental control of humidity and temperature was exercised in the filter weighing room. Analysis of the filters was performed satisfactorily for the most part; however, five laboratories did not follow EPA recommended procedures. One laboratory was found to be in too close proximity to a coal storage pile, and the severe dust problem adversely affected its operation.

Many of the agencies found deficient are now planning implementation of the new EPA guidelines pertaining to the State and Local Air Monitoring Stations/National Air Monitoring Stations (SLAMS/NAMS) network, to Prevention of Significant Deterioration (PSD) monitoring, and to Special Purpose Monitoring (SPM). Therefore, a revised Quality System Audit should be performed in the future to verify the implementation of the new guidelines.

SECTION 3

QUALITY CONTROL REFERENCE SAMPLE AUDITS

Regularly scheduled Quality Control Reference Sample Audits have been carried out for the following analyses or measurements: (1) sulfate/nitrate ($SO_4^=/NO_3^-$) analysis; (2) sulfur dioxide (SO_2) analysis; (3) nitrogen dioxide (NO_2) analysis; (4) carbon monoxide (CO) analysis; (5) weighing performance; and (6) Hi-Vol flow rate measurement.

The tables appearing in this section list all the surveys performed in the first three years of the program by date. Participating laboratories in each survey are indicated by a check (✓) mark. These tables also include the new Eastern QA participants starting at the end of 1978.

In the chemical analysis survey for $SO_4^=/NO_3^-$, SO_2, NO_2, and CO, Rockwell obtains from commercial vendors, either directly or through EPA, multiple sets of the appropriate samples. These samples are then submitted for analysis to participating laboratories. Ten replicate samples are first analyzed at Rockwell, and the mean value of the analyses is by definition the "true" value. The results of all the participants are compared to this "true" value to determine their accuracy.

To assure the correctness of the Rockwell "true" value, several internal and external quality control procedures are used. Internal quality control procedures in the Rockwell laboratory include comparison of analyses of replicate samples, comparison of every new stock standard solution with the old solution, duplicate calibration curves before and after analysis, analysis of quality control standards every 10 samples, and maintenance of routine quality control charts on calibration parameters to establish laboratory control limits. External quality control is provided by comparing the Rockwell "true" value with the mean value obtained through replicate sample analysis by either

Quality Assurance Division (QAD-EMSL) laboratory or by the vendor. This comparison is included in each report.

Laboratory performance is evaluated by several methods. The most direct method is to compare the concentration determined by each laboratory with the "true" value as determined by Rockwell. Linear graphs are prepared in which the laboratory values are plotted against the "true" values. The slope, intercept, and correlation coefficient for each laboratory line are then tabulated as indices of performance. Perfect agreement between a laboratory's results and Rockwell's "true" value for all analyses results in a straight line with unit slope, zero intercept, and a correlation coefficient equal to 1.0000.

The slope of the line is a good measure of overall analytical accuracy, provided that the intercept is small compared to the concentrations being analyzed. If the slope is near 1.0, a large intercept indicates a bias in the analysis which might be caused by such errors as incorrect blank corrections or contaminates in the water supply. The detailed results for the performance of each laboratory are tabulated in individual quarterly reports describing the interlaboratory survey for a given pollutant.

A second method for evaluating laboratory performance is to calculate average percent differences between the laboratory analysis values and the "true" values. The average percent difference and the standard deviation of the individual percent differences are tabulated for each laboratory, that participated in the quarterly audit, as measures of analytical error. The calculations are explained in detail in the revised SLAMS regulations (EPA 1979). The major difference between the Rockwell procedure and that described in the SLAMS regulations is that the latter specifies three concentration ranges: 0.2 - 0.3 µg/ml; 0.5 - 0.6 µg/ml; and 0.8 - 0.9 µg/ml for both SO_2 and NO_2. In the current Rockwell program there are three to six samples and the concentrations of the audit samples cover a much wider range. Another difference from the EPA regulations is that our program includes audits of CO, $SO_4^=$, and NO_3^- analysis, none of which is required by the new regulation.

The performance of each laboratory participating in the surveys is summarized below for each of the pollutants independently. Data are presented in tables showing average percent difference ($\bar{d}_j$), and standard deviation (S_j).

The average percent difference and standard deviation for each laboratory are computed using the equations:

$$\bar{d}_j = \frac{1}{n}\sum_{i=1}^{n} d_i \qquad \text{(Eq. 3.1)}$$

$$S_j = \sqrt{\frac{1}{n-1}\left[\sum_{i=1}^{n} d_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} d_i\right)^2\right]} \qquad \text{(Eq. 3.2)}$$

where n is the number of audit samples and d_j is the percent difference for each sample. The value of d_j is calculated using the equation $d_i = 100\ (Y_i - X_i)/X_i$, where Y_i and X_i are the concentrations of the i-th sample determined by the laboratory and by Rockwell, respectively.

Composite averages are obtained by combining the quarterly results of each agency using the following equations:

$$\bar{D} = \frac{\sum_{j=1}^{k} n_j \bar{d}_j}{\sum_{j=1}^{k} n_j} \qquad \text{(Eq. 3.3)}$$

$$S_a = \sqrt{\frac{\sum_{j=1}^{k} (n_j - 1)\ S_j^2}{\sum_{j=1}^{k} (n_j - 1)}} \qquad \text{(Eq. 3.4)}$$

where $\bar{D}$ and S_a are the composite average percent deviation and the standard deviation, respectively, n_j is the number of samples analyzed by the j-th laboratory, and k is the total number of participating laboratories. In order to avoid undue bias of the results, a laboratory is declared an outlier and the data are not used for computing composite averages if $\bar{d}_j$ or S_j for that laboratory is equal to or greater than 100 percent. The latter value was chosen subjectively so as to eliminate only grossly erroneous data (e.g., decimal point error in the reported data).

SULFATE/NITRATE ANALYSIS

All the sulfate/nitrate performance surveys performed since the inception of this program are summarized in Table 2. This performance survey requires participating laboratories to analyze a set of four to six filter strips spiked with varying amounts of sulfate and nitrate ions. At least 10 sets of filters presumed to be identical to those analyzed by the laboratories are analyzed by the Rockwell Chemistry Laboratory using the methylthymol blue procedure for $SO_4^=$ and the copperized cadmium reduction method for NO_3^-. In the interpretation of results, no bias or adjustment is made for the fact that laboratories included in the surveys use methods different from Rockwell's. All laboratories use EPA accepted methods which presumably give equivalent results, making such adjustments unnecessary.

Table 3 lists the various comparison parameters for $SO_4^=$ audits, and Table 4 lists the comparison parameters for NO_3^- audits. These parameters are given for each laboratory for the four surveys in the reporting period. To preserve anonymity, the identities of the laboratories are not shown.

Figure 1 shows graphs of $\bar{D}$ and $\bar{D} \pm S_a$ for the composite data of all the agencies as a function of time. The curves for $\bar{D} \pm S_a$ describe a band of one standard deviation above and below $\bar{D}$ which is about 20 percent for both $SO_4^=$ and NO_3^-. In looking at the composite graph for $SO_4^=$ and NO_3^-, it is evident that during the three years of the program the band width has remained quite constant.

TABLE 2. LIST OF PARTICIPANTS IN THE INTERLABORATORY PERFORMANCE SURVEY FOR $SO_4^=/NO_3^-$*

Agency	Survey Date by Quarter										
	4/76†	1/77†	2/77†	3/77†	4/77††	1/78††	2/78††	3/78	4/78	1/79	2/79
Western											
Arizona State	✓‡	✓‡	✓‡	✓‡	✓‡	✓	✓	✓	✓	✓	✓
Colorado State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy & Environmental Resource Consultants, Inc.							✓	✓	✓	✓	✓
Montana State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Mexico State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Dakota State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northern Testing Lab	✓	✓	✓	✓	✓	✓					
South Dakota State						✓	✓	✓			
Ute Research			✓	✓	✓	✓	✓	✓	✓	✓	
Eastern											
Indiana State									✓	✓	
Maryland State									✓	✓	
Pennsylvania State									✓	✓	
Philadelphia City									✓	✓	
Virginia State									✓	✓	
West Virginia State									✓	✓	
EPA, RTP	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

* a check denotes that the agency participated in the survey

† summarized in 1st annual report

†† summarized in 2nd annual report

‡ SO_4 only

TABLE 3. SUMMARY OF AGENCY PERFORMANCE FOR $SO_4^=$ AUDITS

Agency	Quarter							
	3/78		4/78		1/79		2/79	
	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j
A	8.5	4.3	2.9	3.5	3.8	5.6	-	-
B	-26.9	43.9	3.9	16.0	14.4	39.8	2.9	7.8
C	-12.1	29.8	12.8	16.3	-1.6	6.0	16.6	13.2
D	2.2	1.8	-1.8	5.9	2.4	25.0	-3.0	6.0
E	63.4	19.1	-6.5	4.4	-10.5	7.5	-6.6	7.4
F	8.9	5.9	-6.8	7.0	-2.7	3.5	-4.1	11.9
G	5.8	1.6	4.3	12.7	-1.0	2.9	-5.9	10.5
H	-10.8	14.5	-	-	5.1	10.3	-	-
M	-	-	2.1	15.9	-4.4	7.5	-	-
N	-	-	8.2	7.6	28.9	53.6	-	-
O	-	-	11.7	7.2	44.4*	124.8*	-	-
P	-	-	-54.3	30.1	-0.4	4.9	-	-
Q	-	-	-19.6	48.6	-8.0	28.8	-	-
R	-	-	0.9	8.6	-	-	-	-
EPA	5.2	4.4	5.8	6.9	5.8	6.9	3.1	5.6
Composite	4.9	19.6	-2.8	18.1	2.5	22.3	0.4	9.3

* outlier defined as $|\bar{d}_j| \geq 100$, or $S_j \geq 100$

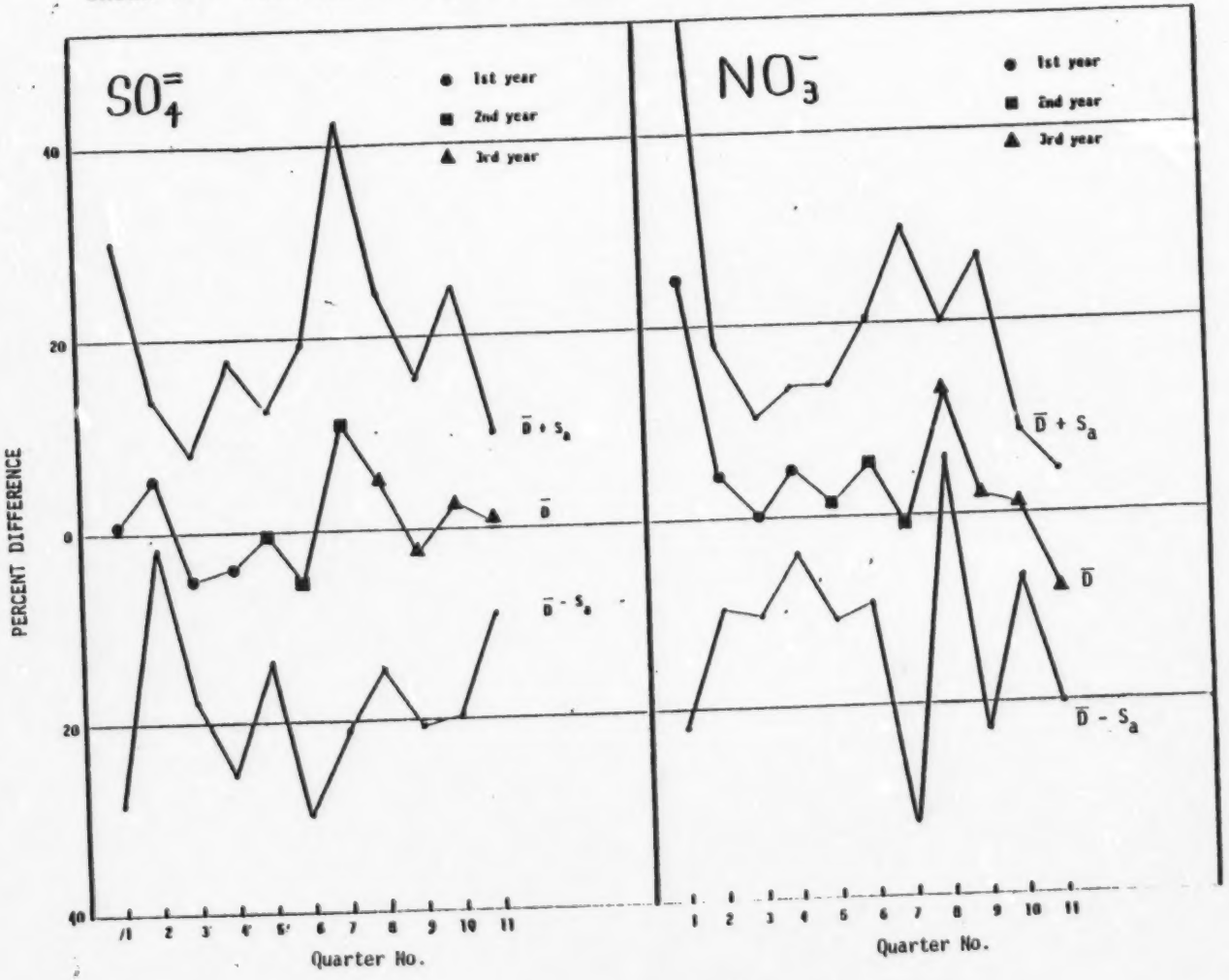
TABLE 4. SUMMARY OF AGENCY PERFORMANCE FOR NO_3^- AUDITS

Agency	Quarter							
	3/78		4/78		1/79		2/79	
	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j
A	16.3	3.4	6.3	13.2	2.2	2.8	-6.8	8.9
B	237.1*	182.1*	-21.4	20.1	1.2	3.3	-55.2	25.3
C	22.3	14.9	18.6	31.4	-10.7	10.0	-4.0	11.4
D	7.1	5.6	-2.2	8.8	-8.1	9.6	1.5	7.3
E	5.9	6.5	-2.7	6.3	2.8	5.9	5.2	7.7
F	17.8	6.4	-5.1	2.1	3.7	6.0	2.3	5.9
G	11.8	3.3	6.1	7.6	4.2	3.0	-	-
H	14.0	5.1	-	-	-	-	-	-
M	-	-	-26.5	57.4	11.0	3.7	-	-
N	-	-	6.9	6.5	3.3	12.6	-	-
O	-	-	6.2	4.2	-42.0	15.5	-	-
P	-	-	-17.0	12.7	2.2	4.0	-	-
Q	-	-	52.1	56.4	1.8	3.8	-	-
R	-	-	1.2	2.3	-	-	-	-
EPA	9.2	4.5	7.4	4.4	7.4	4.4	2.4	5.5
Composite	13.0	7.1	2.1	24.6	1.0	7.6	7.8	12.1

* outlier defined as $|\bar{d}_j| \geq 100$, or $S_j \geq 100$

FIGURE 1

Composite quarterly performance evaluation of the $SO_4^=$ and NO_3^- audits (Quarters are listed consecutively starting with 4th Quarter 1976 and percent difference is shown as a function of time since the beginning of the program).



SULFUR DIOXIDE

Sulfur dioxide samples consist of standard ampules containing freeze-dried solutions of sodium sulfite and tetrachloromercurate. The "true" value for each sample is obtained by the Rockwell Laboratory by analysis of at least 10 replicate samples. The usual quality control procedures were used for each analysis. Table 5 lists all the participants in the SO_2 surveys since the beginning of the program, including the Eastern agencies which entered later and participated in the quarters of 4/78 and 2/79 only. Table 6, summarizes the SO_2 results for the third year of the program. Approximately sixty-eight percent of all the analyses agree with the Rockwell analyses within the percentage limits defined by $\bar{D} + S_a$. For SO_2 this band is approximately plus or minus 20 percent. The results are presented graphically in Figure 2a.

NITROGEN DIOXIDE ANALYSIS

Nitrogen dioxide samples consist of standard ampules containing solutions of sodium nitrite. The "true" value for each sample is obtained by the Rockwell Laboratory by analysis of at least 10 replicate samples. The usual quality control procedures are followed for each analysis. Table 7 lists the agencies participating in this interlaboratory survey since the beginning of the program. It also indicates the introduction of the Eastern agencies into the surveys of 4/78, 1/79, and 2/79.

Table 8 summarizes the performance results for the third year of the program. A composite $\bar{D}$ and S_a is computed for all the agencies and is presented in Figure 2b, together with the composite results since the beginning of the program. The results for NO_2 continue to show a better performance than the $SO_4^=/NO_3^-$ analysis results and the SO_2 analysis results. The band defined by $\bar{D} \pm S_a$ is approximately plus or minus 7 percent although in the quarter of 4/78 the band is wider ($\pm$ 12%). This discrepancy can be attributed to the introduction of new participating agencies. The subsequent surveys of 1/79, 2/79, and 3/79 again show the narrower band of results.

TABLE 5. LIST OF PARTICIPANTS IN THE INTERLABORATORY PERFORMANCE SURVEY FOR SO_2

Agency	Survey Date by Quarter									
	4/76*	1/77§	2/77*	3/77*	4/77‡	1/78‡	2/78‡	3/78‡	4/78	2/79
Arizona State	✓			✓	✓	✓	✓	✓	✓	✓
Colorado State	✓		✓	✓	✓	✓	✓	✓	✓	✓
Energy & Environmental Resource Consultants, Inc.							✓	✓	✓	✓
Lockheed			✓							
Montana State	✓		✓	✓	✓	✓	✓	✓	✓	✓
New Mexico State	✓		✓	✓	✓	✓	✓	✓	✓	✓
North Dakota State	✓		✓	✓	✓	✓	✓	✓	✓	✓
Northern Testing Lab	✓		✓	✓	✓	✓				
Northrop Services Inc.					✓		✓	✓		
South Dakota State	✓		✓	✓	✓	✓	✓	✓	✓	✓
Wyoming State	✓		✓	✓	✓	✓	✓	✓	✓	✓
Yellowstone County	✓		✓	✓	✓	✓	✓	✓	✓	✓
Cincinnati City									✓	✓
Dayton City									✓	✓
West Virginia State									✓	✓
Indiana State									✓	
Maryland State									✓	✓
Pennsylvania State									✓	✓
Philadelphia City									✓	✓

(Continued)

TABLE 5 (Continued)

Agency	Survey Date by Quarter									
	4/76*	1/77§	2/77*	3/77*	4/77‡	1/78‡	2/78‡	3/78‡	4/78	2/79
									✓	✓
Fairfax County								✓	✓	✓
EPA, RTP	✓		✓	✓	✓					

§ audit omitted this quarter because of a lack of audit samples

* 1st annual report

‡ 2nd annual report

TABLE 6. SUMMARY OF AGENCY PERFORMANCE FOR SO_2 AUDITS

Agency	Quarter			
	4/78		2/79	
	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j
A	-8.6	25.0	20.0	25.6
B	18.1	9.5	-6.6	19.2
C	-0.8	11.7	2.5	1.3
D	-7.9	24.4	-8.6	26.5
E	-10.0	10.9	-12.3	18.7
F	-16.2	17.9	8.2	22.2
G	-15.0	24.6	6.9	14.5
H	-1.4	5.7	-32.3	1.0
I	-0.3	18.0	6.9	1.8
M	23.8	21.1	-2.9	36.4
N	-31.5	15.3	12.2	9.0
O	-36.3	37.2	-4.7	8.4
P	6.5	10.0	-	-
Q	-4.9	12.7	0.6	2.7
R	17.2	31.7	34.9	73.4
S	-5.0	12.3	9.1	15.6
T	-22.1	19.3	-3.0	7.5
EPA	1.6	9.3	-2.8	3.7
Composite	-5.2	19.4	2.3	24.9

TABLE 7. LIST OF PARTICIPANTS IN THE INTERLABORATORY PERFORMANCE SURVEY FOR NO_2

Agency	Survey Date by Quarter										
	1/77†	2/77†	3/77†	4/77††	1/78††	2/78††	3/78††	4/78	1/79	2/79	3/79
Arizona State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Colorado State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy & Environmental Resource Consultants, Inc.						✓	✓	✓	✓		✓
Montana State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Mexico State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Dakota State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Northern Testing Lab	✓	✓	✓	✓	✓						
South Dakota State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wyoming State	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indiana State								✓	✓	✓	
Pennsylvania State								✓	✓		
Philadelphia City #1								✓	✓	✓	
Maryland State								✓	✓	✓	
Virginia State								✓	✓	✓	
Fairfax County								✓	✓	✓	
Cincinnati City								✓	✓	✓	
Philadelphia City #2										✓	
Dayton, Ohio										✓	
EPA, RTP	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

† 1st annual report

††2nd annual report

TABLE 8. SUMMARY OF AGENCY PERFORMANCE FOR NO_2 AUDITS

Agency	Quarter							
	4/78		1/79		2/79		3/79	
	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j
A	-	-	2.8	1.2	222.2*	13.6	2.7	3.3
C	2.8	1.0	0.9	2.5	3.4	4.3	10.0	4.6
D	5.1	2.0	-0.6	1.2	2.2	3.0	0.1	4.1
E	0.9	2.5	1.6	1.6	-	-	5.1	7.0
H	7.1	3.5	-20.5	5.1	-42.6	23.1	-3.5	0.8
I	2.5	1.1	0.9	1.1	3.9	2.4	0.8	7.4
J	14.7	16.7	16.9	12.2	4.9	4.3	7.4	9.7
L	5.4	2.2	5.8	9.1	6.8	4.4	3.8	0.9
M	-14.6	44.6	4.6	7.6	3.6	4.0	-	-
N	0.3	0.9	1.5	1.4	-	-	-	-
O	0.0	1.7	0.5	1.2	4.9	3.8	-	-
P	-1.2	1.3	-0.5	2.1	2.6	2.1	-	-
Q	-1.2	3.0	-11.1	1.3	-3.5	4.0	-	-
R	1.3	1.7	-0.3	1.7	0.7	2.6	-	-
S	-4.8	1.4	-5.3	1.6	3.2	3.7	-	-
T	1.3	4.3	-6.3	7.5	2.5	4.2	-	-
EPA	0.3	1.3	-0.6	1.1	2.1	3.2	-2.3	1.6
Composite	0.3	12.1	-0.6	4.9	-0.1	6.9	2.6	5.1

* outlier defined as $|\bar{d}_j| \geq 100$, or $S_j \geq 100$

CARBON MONOXIDE ANALYSIS

Table 9 lists all the participants in the CO survey by quarter of performance. Carbon monoxide samples are contained in 0.85 m^3 (30 ft^3) aluminum cylinders. Three different concentrations were submitted for analysis in each survey. Replicate analyses were performed in the Rockwell Quality Assurance Laboratory using a Bendix nondispersive infrared analyzer, and an NBS Standard Reference Material (SRM) cylinder containing 95.0 ppm CO in air used as the standard. The "true" value was established by analysis of at least five cylinders of each concentration.

The results of all the CO surveys were for the most part very satisfactory. Table 10 presents summary data for the surveys of 3/78 and 1/79 which were performed during the third year of this program. Composite results are shown graphically in Figure 2c. In this figure, it is evident that the pooled standard deviation has been less than 10 percent since the beginning of the program. In the last year, the performance was approximately plus or minus 5 percent which is probably as accurate an agreement as is possible.

The close agreement between the various agencies and Rockwell for this particular survey is probably because the agencies calibrate their analyzers with CO cylinders which contain CO at ambient levels and require no further dilution.

WEIGHING SURVEY

The third weighing interlaboratory survey was conducted this year for both the Western and Eastern Quality Assurance Programs. The survey was initiated in February and completed in June 1979. Table 11 lists the participants in both the annual weighing and Hi-Vol performance surveys. Twelve sets of three weights, each containing a 1g, 2g, and 5g weight were obtained from Van Waters and Roger Scientific. The weights were slightly modified by filing away some of the mass. After thorough cleaning, each mass was weighed seven times on two different balances (one capable of weighing to 0.01 mg and the other a microbalance) over a period of several days by the Rockwell Chemistry and Rockwell Quality Assurance Laboratories. Each balance was calibrated immediately prior to use with an NBS-certified set of Class "S"

TABLE 9. LIST OF PARTICIPANTS IN THE INTERLABORATORY PERFORMANCE SURVEY FOR CO

Agency	Survey Date by Quarter								Agency	Quarter
	4/76*	1/77*	3/77*	4/77†	1/78†	2/78†	3/78	1/79		1/79
Albuquerque	✓	✓	✓	✓	✓	✓	✓	✓	Alexandria City	✓
Arizona State	✓	✓	✓	✓	✓	✓	✓	✓	Delaware State	✓
Colorado State	✓	✓	✓	✓	✓	✓	✓	✓	Dayton City	✓
Montana State		✓	✓	✓	✓	✓	✓	✓	Allegheny County	✓
New Mexico State	✓	✓	✓	✓	✓	✓	✓		Maryland State	✓
Utah State	✓	✓	✓	✓	✓	✓	✓	✓	Philadelphia City	✓
Yellowstone County	✓								Washington DC	✓
EPA, RTP	✓	✓	✓	✓	✓	✓	✓	✓	Pennsylvania State	✓
									Fairfax County	✓
									Cincinnati City	✓
									Virginia State	✓
									West Virginia State	✓
									Indiana State	✓

* 1st annual report

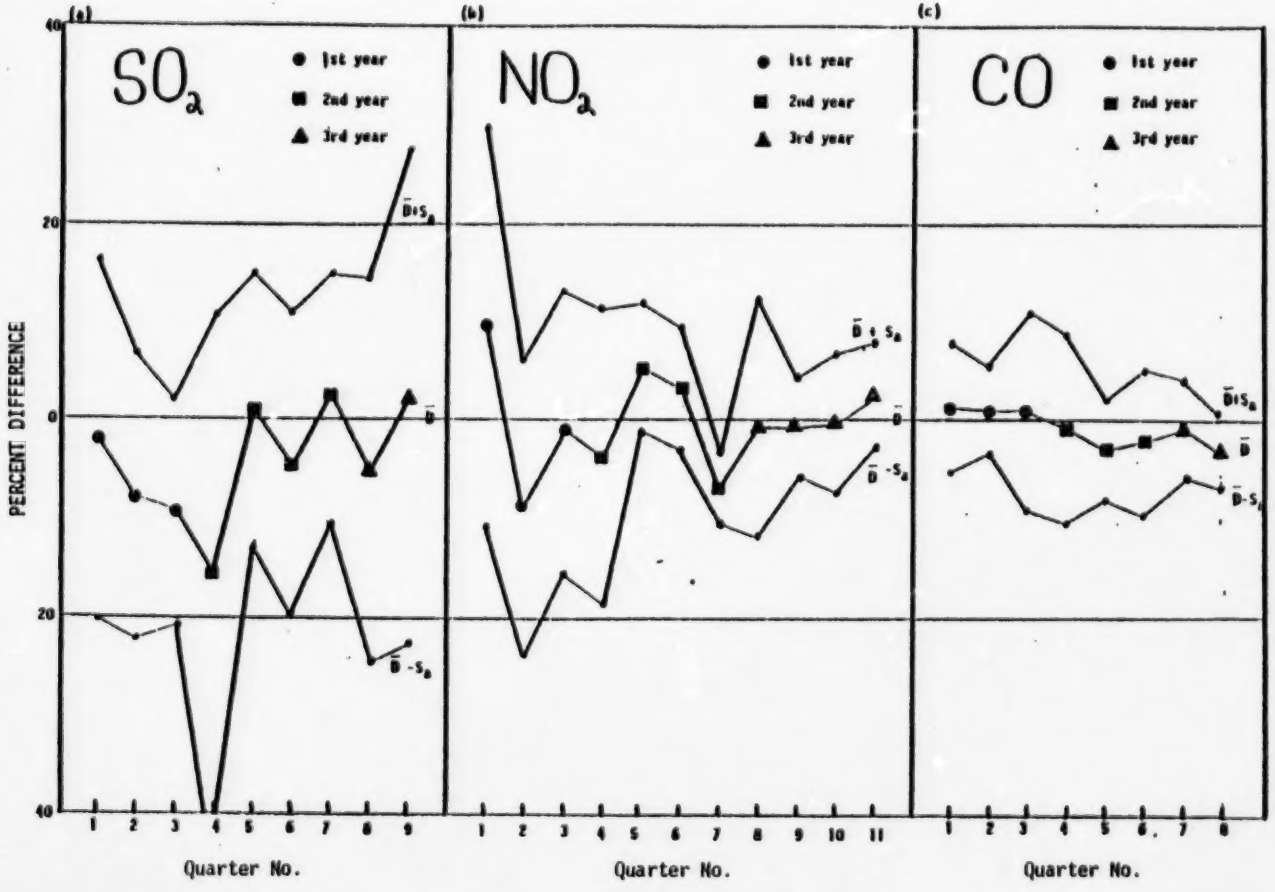
† 2nd annual report

TABLE 10. SUMMARY OF AGENCY PERFORMANCE FOR CO AUDITS

Agency	Quarter			
	3/78		1/79	
	$\bar{d}_j$ (%)	S_j	$\bar{d}_j$ (%)	S_j
A	-2.6	2.0	-1.2	1.0
C	2.2	9.1	0.5	2.4
D	-1.7	0.8	-6.3	1.4
E	-0.7	5.8	-0.3	3.9
F	0.8	4.2	-1.7	2.3
H	-	-	0.7	2.8
I	-	-	-3.4	2.1
J	-	-	-0.7	0.6
K	-	-	-1.1	4.4
L	-	-	-1.5	1.1
M	-	-	0.4	3.3
N	-	-	-8.0	2.0
O	-	-	-9.4	7.2
P	-	-	-3.0	1.7
Q	-	-	-7.2	6.8
R	-	-	-1.2	3.4
S	-	-	-3.2	2.8
T	-	-	-5.1	3.4
EPA	-1.4	0.8	-3.4	0.3
Composite	-0.7	5.2	-3.1	3.7

FIGURE 2

Composite quarterly performance evaluation of the SO_2, and NO_2, and CO audits (quarters are listed consecutively starting with (a) 4/76, (b) 1/77, and (c) 4/76, and percent difference is shown as a function of time since the beginning of the program).



weights. The mean weight and standard deviation of each mass were obtained from these weighing data. When these masses are used in subsequent surveys, each mass is weighed before and after it is sent to the various agency participants. This procedure allows verification that no significant change in weight has occurred during transit.

Table 12 is taken from the third Weighing Audit report. This table summarizes the results of the survey which included both groups from the East and West. Of the weighings reported by the participants, 94 percent were within target range (± 1 mg) and 69 percent were within sample range (± 0.5 mg).

HIGH-VOLUME FLOW RATE CALIBRATION SURVEY

The third Hi-Vol flow rate calibration survey was conducted in the first half of 1979. A list of all participants for this survey is given in Table 11. In the initial phase of the survey, Rockwell submitted audit devices to participating agencies together with a test protocol.

Flow calibration devices were then calibrated at the Rockwell EMSC QA Laboratory using a Roots-Meter. Calibration curves were obtained by plotting the theoretical flow, Q_{theo}, in cubic meters per minute (CMM) vs. square root of the pressure drop, $\sqrt{\Delta P}$, in inches of water at a barometric pressure of 760 mm Hg and a temperature of 298°K. The theoretical flow was obtained from the actual flow measured in the laboratory, corrected for barometric pressure and the ambient temperature at the time of the orifice calibration. Participants were asked to install the calibration device and to measure the flow as they would normally do. For each flow measurement, additional information is reported concerning the basis of the measured flow (ambient, standard, or other), as well as the pressure drop and the barometric pressure and ambient temperature at the field site at the time of flow calibration. The true flow computed for the agency is compared to the true flow determined by Rockwell using the calibration curves discussed above. The percent difference is calculated in the following way:

$$\% \text{ Diff} = \frac{\text{Agency flow - Rockwell Flow}}{\text{Rockwell Flow}} \times 100 \qquad \text{(Eq. 3.6)}$$

The detailed results of the actual % Diff per site are given in the Annual Hi-Vol Report. Figure 3 presents a composite of the three Hi-Vol Surveys conducted since the inception of this program. The histograms represent groups of sites whose reported percent difference (as defined above) falls within a certain range. The height of the histograms represents the fraction of sites (when total population in a particular survey ≡ 1.0), and the numbers in each histogram box are the actual numbers of sites involved. Figure 3 illustrates how performance has improved in the three years of the program. In the first annual report only 20 percent of the surveyed sites reported errors of less than 5 percent, whereas in the third annual survey 56 percent reported errors of less than 5 percent. Note, however, that the first two annual surveys included only 40 sites, whereas the 3rd annual report included 126 participating agencies as a result of the Eastern Groups joining the program. At the same time, it is worthwhile to observe that in the first annual report 27.5 percent of the sites reported errors greater than or equal to 15 percent, and in the second annual report only one site (2.6% of the sample) reported an error larger than 15 percent. In the third annual survey 8 percent of the sites reported errors in excess of 15 percent. This increase is probably due to the inclusion of new participating agencies.

TABLE 11. LIST OF PARTICIPANTS IN THE PERFORMANCE AUDITS FOR WEIGHING AND HI-VOL FLOW CALIBRATION

Agency	Survey and Date by Quarter					
	Weighing			Hi-Vol		
	1/77*	1/78†	1/79	1/77*	1/78†	1/79
Western						
Albuquerque	✓	✓	✓	✓	✓	✓
Arizona State	✓	✓	✓	✓	✓	✓
C-a	✓	✓	✓	✓	✓	✓
C-b	✓	✓	✓	✓	✓	✓
Colorado State	✓	✓	✓	✓	✓	✓
Energy & Environmental Resources Consultants, Inc.			✓		✓	✓
Lawrence Rad. Labs			✓			
Montana State	✓	✓	✓	✓	✓	✓
Montana Power Co.				✓	✓	✓
New Mexico State	✓	✓	✓	✓	✓	✓
North Dakota State	✓	✓	✓	✓	✓	✓
Northern Testing Lab	✓	✓				
South Dakota State	✓	✓	✓	✓	✓	✓
Ua/Ub	✓	✓	✓	✓	✓	✓
Ute Research	✓	✓	✓	✓	✓	✓
Utah State	✓	✓	✓	✓	✓	✓
Wyoming State	✓	✓	✓	✓	✓	✓
Yellowstone County						
Eastern			✓			✓
Maryland			✓			✓
Delaware			✓			✓
Philadelphia City			✓			✓
Dayton, Ohio						

(Continued)

TABLE 11. (Continued)

Agency	Survey and Date by Quarter					
	Weighing			Hi-Vol		
	1/77*	1/78†	1/79	1/77*	1/78†	1/79
Cincinnati, Ohio			✓			✓
Indiana State			✓			✓
Pennsylvania State			✓			✓
Allegheny County			✓			✓
West Virginia State			✓			✓
Virginia State			✓			✓
Alexandria, Virginia			✓			
Fairfax County			✓			✓
Washington, DC			✓			

* first annual report

† second annual report

TABLE 12. SUMMARY OF WEIGHING SURVEY

Agency Code*	ΔW/mg x 10†			Target Range††	Sample Range††
	1 g	2 g	5 g		
A	-1	-1	-2		
B	+4	+6	+3		-
C	-8	-3	-7		- -
D	+1	+3	+2		
E	+1	+1	-1		
F	-1	+4	+3		
G	-1	0	+1		
H	-1	+2	-2		
I	-5	-5	-3		
J	-7	-11	-12	- -	- - -
K	+3	+4	+4		
L	0	+5	+8		-
M	-2	+1	+2		
N	-1	-1	-1		
O	+3	+1	+2		
P	-8	-8	-10		- - -
Q	+9	+5	+4		-
R	-8	-8	-4		- -
S	+2	+4	+1		
T	-6	-5	-4		-
U	-7	-6	-10		- - -
V_1	+1	0	-1		
V_2	0	+2	-2		
V_3	-1	-1	-1		
W	+15	-16	-7	- -	- - -
X	-5	-5	-6		-
Y	0	0	0		

(Continued)

TABLE 12. (Continued)

Agency Code*	ΔW/mg x 10†			Target Range††	Sample Range††
	1 g	2 g	5 g		
Z	-5	-6	-7		- -
AA	0	+8	+9		- -
BB	-30	-26	-27	- - -	- - -

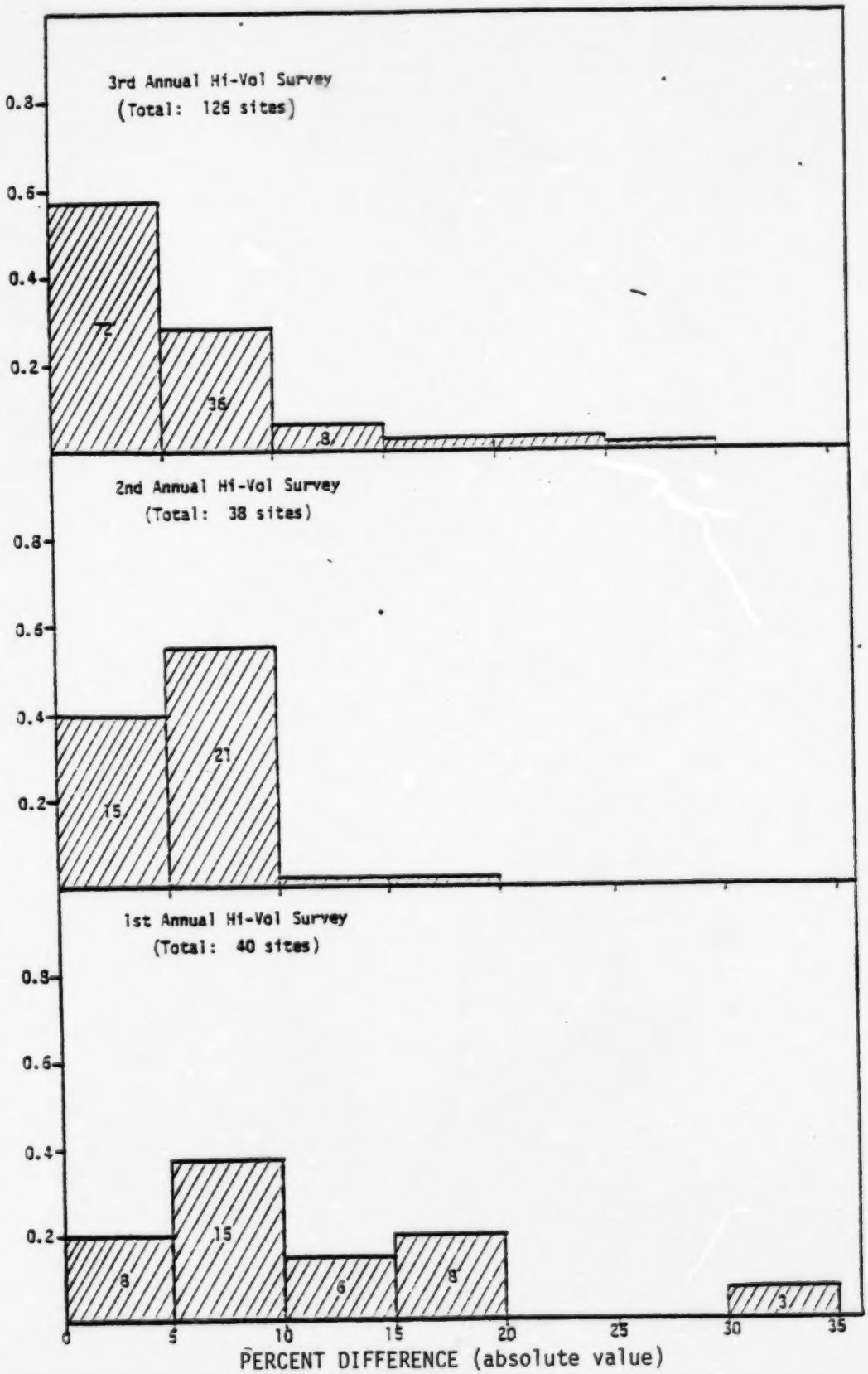
* multiple entries from same agency indicate weighings using different balances

† (Agency-Rockwell) in tenths of milligrams

†† target range: ± 1 mg; sample range: ± 0.5 mg; a (-) sign means weighing is not within designated range

FIGURE 3

Comparative performance in the three Annual Hi-Vol audits (the number in each rectangular represents actual number of agencies).



SECTION 4

PERFORMANCE AUDITS

Performance audits of air monitoring stations operated by participating groups is a major task in the Western and Eastern QA programs. Table 13 shows a list of all the sites audited and the dates of the audits during the period between September 1978 and September 1979. The audit procedures, the audit devices, operational checks, and the standards used in the field audits were described in the first annual report, and hence the information will not be repeated here.

The format for reporting audit results has undergone considerable change during the course of the program. The method adopted after June 1978 (at the request of the EPA), compares the concentrations delivered to the analyzer from the audit device to those predicted from the observed instrumental response according to the latest station multipoint calibration. Mathematically, the results are expressed in the form $C_2 = \alpha + \beta C_1$, where C_2 is the station concentration, C_1 is the audit concentration, β is the slope, and α is the intercept. Audit reports show graphs of C_2 vs. C_1, and the values of α and β are given in tabular form (perfect match $\beta = 1$, $\alpha = 0$). In this method of presentation, β is non-dimensional, and its value is independent of the analyzer range and the units used to express analyzer output.

The percent difference between station concentrations is expressed in terms of the magnitude of α and β by means of the equation:

$$\% \text{ diff} = d_j = 100 \times \frac{C_2 - C_1}{C_1} = 100 \left[(\beta - 1) + \frac{\alpha}{C_1} \right] \qquad \text{(Eq. 4.1)}$$

In order to evaluate the station performance, the percent difference is calculated at the nominal full scale of the analyzer (e.g., $C_1 = 0.5$ ppm for most

NO analyzers). Since the magnitude of α/C_1 is normally small compared to β-1, the percent difference is approximately a constant represented by the quantity 100 (β-1). This relationship makes β a useful comparison parameter.

The revised SLAMS regulations explains in detail the data analysis to be performed with the audit results (EPA 1979). A summary of the required data reduction steps for each quarterly audit of each agency is presented. This computational procedure must be repeated for each audit concentration level.

- Calculate percent difference, d_i:

$$d_i = \frac{C_2 - C_1}{C_1} \times 100 \qquad \text{(Eq. 4.2)}$$

- Calculate the average D of the individual percent differences, d_i, for all k analyzers measuring a specific pollutant and audited during the quarter:

$$\bar{D} = \frac{1}{k} \sum_{i=1}^{k} d_i \qquad \text{(Eq. 4.3)}$$

- Calculate the standard deviation, S_a, of the percentage differences of all k analyzers audited that quarter:

$$S_a = \sqrt{\frac{1}{k-1} \left[\sum_{i=1}^{k} d_i - \frac{1}{k} \left(\sum_{i=1}^{k} d_i \right)^2 \right]} \qquad \text{(Eq. 4.4)}$$

- Calculate the 95 percent confidence interval for the accuracy. ($\bar{D}$), for each reporting organization:

$$\bar{D} - 1.96\, S_a \leq \left\{ \bar{D} \right\} \leq \bar{D} + 1.96\, S_a \qquad \text{(Eq. 4.5)}$$

TABLE 13. SUMMARY OF AUDITS PERFORMED BY ROCKWELL DURING THE PERIOD OCTOBER 1978 TO SEPTEMBER 1979*

AGENCY	SITE	DATE
Western Groups		
C-a	1	12/78, 3/79, 6/79, 9/79
C-b	023	12/78, 3/79, 6/79, 9/79
State of Colorado	CARIH	11/78, 2/79, 6/79, 9/79
	CAMP	11/78, 2/79, 6/79
	Colorado Springs	11/78, 2/79, 6/79
	Greeley	11/78, 2/79, 6/79
	Welby	11/78, 2/79, 6/79
EPA/EMSL	RTP	1/79, 5/79, 8/79
EPA/EMSL (Northrop Services Inc.)	Las Vegas	12/78, 3/79, 9/79
EPA/Corvallis (Ames Laboratories)	Hay Coulee	10/78, 2/79, 8/79
	B & W	10/79
	Greenleaf	8/79
State of Montana	Billings	10/78, 2/79, 5/79, 8/79
	E. Laurel	10/78, 5/79, 8/79
	Hebgen Park	10/78, 2/79, 5/79
	Hwy Junction	10/78, 2/79, 5/79
	Gate	2/79
	Lincoln School	10/78, 2/79, 5/79
	Lion's Park	10/78, 2/79, 5/79
	Lockwood School	8/79
State of New Mexico	Reservation	12/78, 3/79, 6/79, 9/79
	Substation	12/78, 3/79, 6/79, 9/79
	Water Tank	12/78, 3/79, 6/79, 9/79
	State Calib. Office	3/79, 6/79, 9/79

(Continued)

TABLE 13. (Continued)

AGENCY	SITE	DATE
National Oceanic and Atmospheric Administration	Boulder	11/78, 2/79, 6/79
State of North Dakota	Stanton	10/78, 1/79, 5/79, 8/79
	Bismarck	10/78
Ua/Ub	A6	3/79, 6/79, 9/79
State of Utah	Bountiful	10/78, 1/79, 4/79
	Castle Dale	1/79, 4/79, 6/79, 9/79
	Cedar City I	9/78, 12/78
	Cedar City II	12/78, 3/79, 6/79, 9/79
	Huntington	10/78
	Magna	10/78, 1/79, 4/79
	Mills	4/79, 6/79, 9/79
	Ogden	10/78, 1/79, 4/79
	Provo	10/78, 1/79, 4/79
	Salt Lake City	1/79, 4/79
	State Calib.	10/78, 1/79, 4/79
	Vernal	9/79
State of Wyoming	Casper	3/79, 5/79, 9/79
Eastern Groups		
City of Alexandria	Station	11/78
Allegheny County	Hazelwood	1/79
	Downtown	1/79
City of Cincinnati	Ripple Road	5/79
	Sycamore	5/79
City of Baltimore	Read St.	3/79
Baltimore County	Essex	3/79
Dayton, RAPCA	Springfield	5/79
	Northridge	5/79
	Mad River Trailer	5/79
	County Building	5/79

(Continued)

TABLE 13. (Continued)

AGENCY	SITE	DATE
Dayton, RAPCA (Continued)	Salem	5/79
State of Delaware	P-1	2/79
	P-2	2/79
Fairfax County	Station	11/78
State of Indiana	Hammond	5/79
	Indy	5/79
State of Maryland	Baltimore 01	3/79
	Baltimore 02	3/79
	Bethesda 06	3/79
	Suitland 05	3/79
Carrol County, MD (LLL Trailer)	Mount Airy	3/79
Ohio Edison	Adams	4/79
	P. Hills	4/79
	School	4/79
	Anserphone	4/79
Pennelec	Laboratory	4/79
	Parkwood	4/79
	Gas Center	4/79
State of Pennsylvania	Beaver Falls	1/79
	Baden	1/79
	Johnstown	1/79
	Harrisburg	1/79
City of Philadelphia	Laboratory	2/79
	Broad & Spruce	2/79
State of Virginia	ABC Warehouse	11/78
	Va. School	11/78
	Norfolk Airport	11/78
State of West Virginia	Charleston	5/79
	Wheeling	5/79

(Continued)

TABLE 13. (Continued)

AGENCY	SITE	DATE
State of West Virginia (Continued)	Weirton	5/79
	Follasbee	5/79
Washington, DC	DC Lab	11/78
	Library	11/78

* total of 163 audits

The audit reports since August 1978 include tables of $\bar{d}_j$, D, and S_a as well as the upper and lower limits of the 95 percent probability confidence interval, but no further attempt has been made to interpret these data.

For the purpose of this annual report, percent difference at full scale was chosen as the criteria for overall performance, since the intention was to emphasize any improvements which may have occurred in the agencies' calibration accuracy, rather than computing confidence intervals for estimating the validity of air monitoring data.

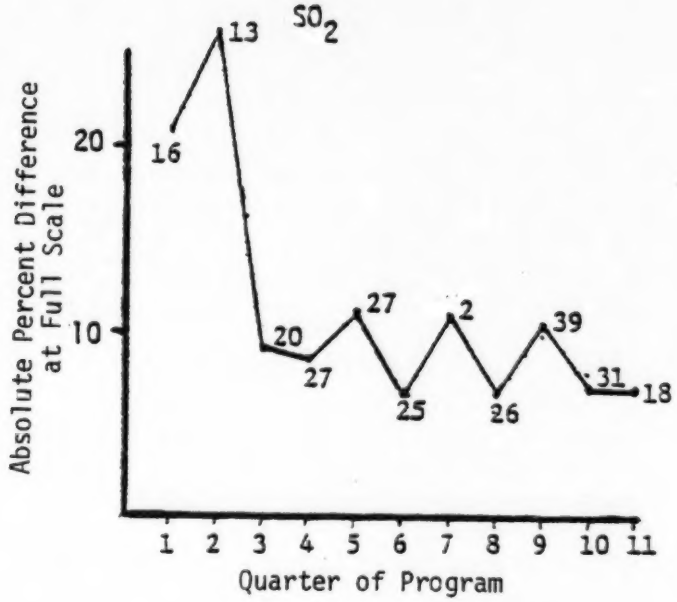
Table 14 provides a summary of performance audits; results are presented separately for the Western agencies and for the Eastern agencies. The table lists the percent of audits in which the error was less than 10 percent. If the performance of West vs. East is compared, it can be concluded that SO_2 measurements are performed with about the same accuracy in all sites; the same applies to CO. For nitric oxide (NO), NO_2, nitrogen oxides (NO_x), and ozone (O_3) measurements, the percentage of audits with errors less than or equal to 5 percent was about the same for all sites, but the percentage of audits with errors less than or equal to 10 percent shows a marked difference. For NO, NO_2, and NO_x, this percentage is 82 percent, 78 percent and 88 percent, respectively for the Western agencies, and for the Eastern agencies it is only 56 percent, 58 percent and 43 percent, respectively. For O_3, the same pattern is observed: 66 percent of all audits in the West show $d_j \leq 10\%$ while only 38 percent of audits in the East show this accuracy. That the Western agencies have participated in this program with quarterly audits for three years while the Eastern agencies have undergone only one audit at each site during the period November 1978 to April 1979 should be emphasized.

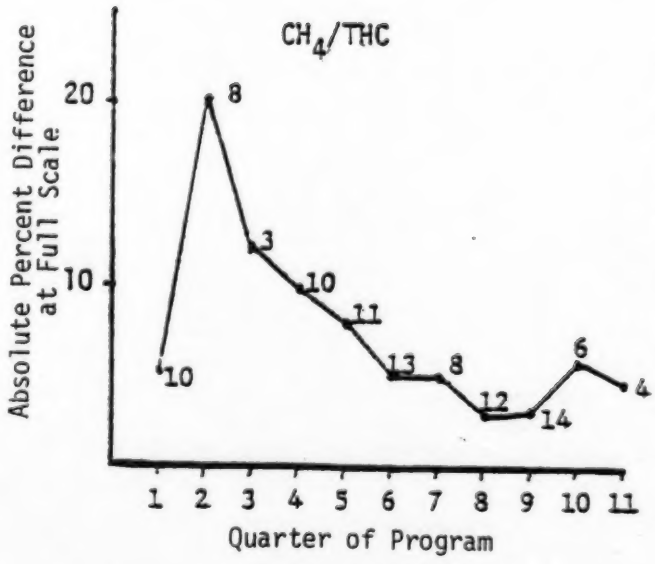
In order to demonstrate the trend in the accuracy of the agencies' calibration, Figure 4 and Figure 5 present the absolute percent difference at full scale for each criteria pollutant vs. the quarter in which audit was performed, since the beginning of the program. Figure 4 shows the results for the three pollutants total hydrocarbons (THC) including methane (CH_4), CO, and SO_2 for which there was basically good performance in both the West and the East. The percent differences shown here are for all the audits per-

formed during any given calendar quarter. Figure 5 presents the results for NO, NO_2, NO_x, and O_3. As indicated above, in those audits the largest difference in performance was found between the West and the East. The Eastern sites received one performance audit each spread through the quarters 4/78, 1/79, and 2/79. Both Figure 4 and Figure 5 re-emphasize the improved performance in monitoring which was previously noted in the second annual report. The average error for all pollutants is shown to be either close to or below 10 percent. For O_3 the improvement that was noticed in the second annual report is clearly evident during the third year, with sustained accuracy of about 10 percent. This record is indicative of improved operational procedure, with operators becoming more familiar with calibrating O_3 monitors. Performance is expected to improve even more as more agencies switch over to ultraviolet (UV) Photometry as their reference method for O_3 calibrations.

TABLE 14. SUMMARY OF PERFORMANCE AUDIT RESULTS

Pollutant	Western Agencies				Eastern Agencies			
	No. of Audits	Average Percent Error	Percent Audits ≤ 5% Error	Percent Audits ≤ 10% Error	No. of Audits	Average Percent Error	Percent Audits ≤ 5% Error	Percent Audits ≤ 10% Error
CH_4	10	4.7	70	100	7	4.4	43	100
CO	36	4.2	50	97	19	6.2	36	89
NO	34	6.8	41	82	16	10.6	38	56
NO_2	36	7.4	31	78	19	10.6	32	58
NO_X	33	5.8	55	88	7	11.4	29	43
O_3	61	9.1	34	66	26	12.8	31	38
SO_2	77	8.1	43	71	32	9.1	38	78
THC	15	2.6	87	93	4	7.1	25	75





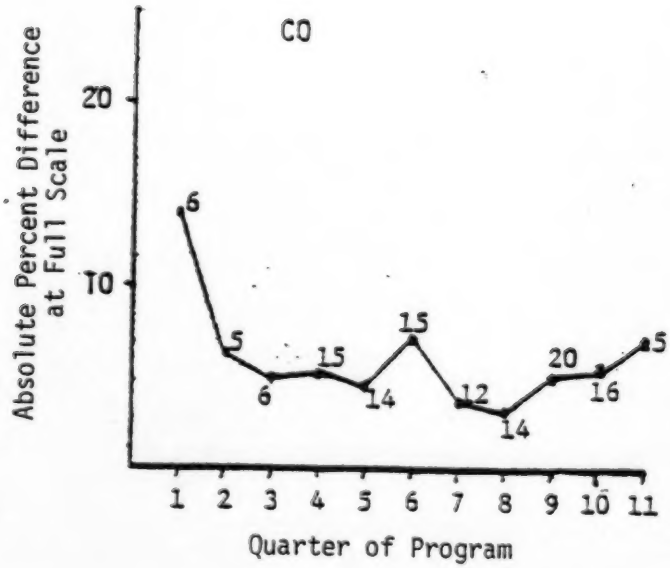


FIGURE 4

Average calibration error vs. Audit cycle for SO_2, CH_4/THC, and CO (the numbers indicate total number of audits per quarter).

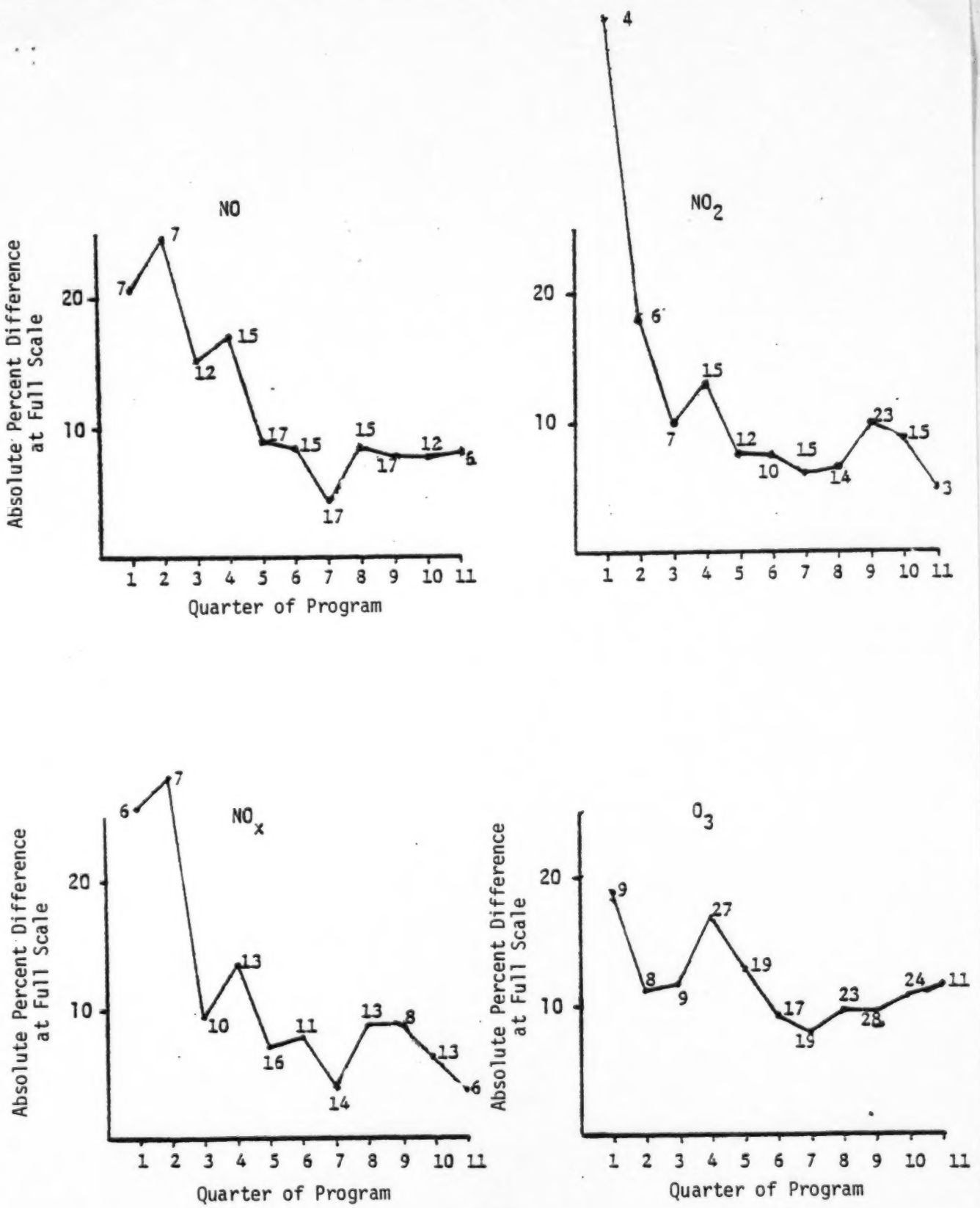


FIGURE 5

Average calibration error vs. Audit cycle for NO, NO_2, NO_X, and O_3 (the number of audits per quarter).

SECTION 5

TECHNICAL ASSISTANCE

In accordance with the provisions of Contract No. 68-02-2412, Rockwell has provided technical assistance to the various participating agencies as requested by the Project Officer. Some of this assistance has been relatively minor, and consisted of discussing various agency problems by telephone, citing literature references, or helping with procedural difficulties.

Much technical assistance is given informally during site evaluations and particularly during field audit visits when the exchange of ideas and information between Rockwell and Agency personnel is often quite extensive.

TECHNICAL ASSISTANCE AREAS

Ultraviolet Photometer Operation

Three agencies have requested assistance with the use of a UV photometer as the standard in O_3 calibration. These agencies were sent a copy of an internal report prepared by Dr. M. Cher on this topic.

Traceability of Standards

Eleven cylinders and one SO_2 permeation tube were received by Rockwell during the reporting period for analysis and certification of NBS traceability. All items received were returned to the appropriate agencies with the required documents.

Special Audits

At the request of the Project Officer, several special audits were performed. In two cases, side-by-side audits of SO_2 monitors were performed, and in another case Rockwell evaluated a new field calibrator for SO_2 in its field audits. One agency requested side-by-side calibration of NO_2 which was performed in the Rockwell QA Laboratory. Another special audit involved calibration of flows for two dichotomous samplers belonging to one agency.

High-Volume Calibration

One agency requested information on calibration of Hi-Vol flows. The information was supplied with a procedure on how to perform such a calibration.

Monitoring Equipment Information

One agency required assistance in choosing hydrogen sulfide (H_2S) monitoring equipment. Technical information on available monitors and their detection methods was provided by Rockwell.

SECTION 6

PLANS FOR (1980)

General plans for (1980) are to continue the current program of Quality Control Reference Sample Audits, Calibration System Audits, and technical assistance. The program was considerably reduced in scope when the Eastern QA program was terminated. Nonetheless, the Western QA program continues with only minimal changes.

As indicated in previous reports, the ultimate purpose of the program is to help the participating groups in improving the quality of their data base. Thus, constant re-evaluation and modifications in the program will be carried out as deemed necessary by the Project Officer and participating agencies.

REFERENCES

U.S. Environmental Protection Agency. 1979. Air Quality Surveillance and Data Reporting. Appendix A, Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS). EPA 40 CFR Part 58. Federal Register. Vol. 44, No. 92, May 10, 1979.